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# Interactive Multimodal Lifelog Retrieval with vitivr at LSC 2021

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## ABSTRACT

The Lifelog Search Challenge (LSC) is an annual benchmarking competition for interactive multimedia retrieval systems, where participating systems compete in finding events based on textual descriptions containing hints about structured, semi-structured, and/or unstructured data. In this paper, we present the multimedia retrieval system vitivr, a long-time participant to LSC, with a focus on new functionality. Specifically, we introduce the image stabilisation module which is added prior to the feature extraction to reduce the image degradation caused by lifelogger movements, and discuss how geodata is used during query formulation, query execution, and result presentation.

## CCS CONCEPTS

• **Information systems** → **Search interfaces**; **Image search**; **Users and interactive retrieval**; **Multimedia databases**; **Information retrieval**; • **Human-centered computing** → **Interactive systems and tools**.

## KEYWORDS

Content-based Retrieval, Multimedia Retrieval, Lifelogging, Lifelog Search Challenge

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## 1 INTRODUCTION

Ubiquitous mobile computing devices equipped with increasingly powerful and diverse sensors endow users with rich opportunities to digitally capture their individual experiences. While this is a boon for the lifelogging community, enabling the recording of increasingly detailed lifelogs, it also comes with the added difficulty when searching for relevant information in this growing amount of data. Such retrieval capabilities are especially important when the lifelogs are supposed to serve as a memory aid.

The diverse and at the same time personal nature of the data contained within a lifelog, however, makes it difficult to quantify the usefulness of any retrieval approach in an automated fashion. Still, the most effective way for such retrieval evaluations comes in the form of interactive campaigns, which comparatively evaluate retrieval system using common settings and standardized infrastructure [21] on realistic retrieval tasks. Modelled after the Video Browser Showdown (VBS) [16, 20, 27], the Lifelog Search Challenge (LSC) [6–8, 18] is such a campaign, and has established itself as a driving force behind the advances in lifelog retrieval.

For this fourth edition of the LSC, we present in this paper the improvements made to the vitivr multimedia retrieval stack [23] in the context of its third participation in this series of events. In particular, we review existing functionality for lifelog retrieval, and introduce new functionality included for LSC 2021. Specifically, we describe image stabilization, which we use to improve spatial feature extraction and potentially image browsing. Furthermore, we elaborate on how we use geodata in the entire querying pipeline.

Since vitivr is a general-purpose system not specifically built for the LSC, some changes and additions to vitivr during the last year are not discussed in this paper. In summary, we have made changes to Cottontail DB [4, 5], experimented with alternative frontends [11] and used the new competition server DRES [21] to evaluate vitivr in-depth [19].

The remainder of this paper is structured as follows: Section 2 gives an overview of vitivr's system architecture and describes its functionality. Section 3 describes the additions to vitivr for LSC 2021 and in Section 4 we discuss the dataset preparation. Section 5

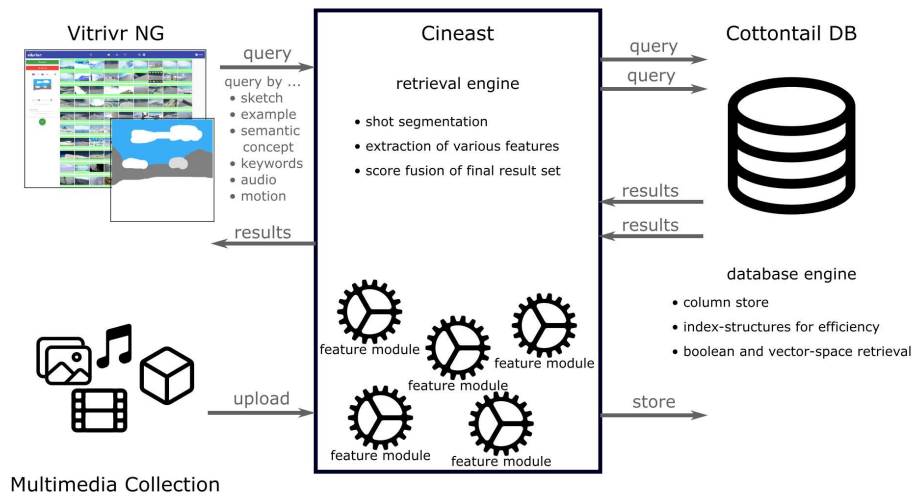


Figure 1: System overview for vitivr and its three major components: vitivr-ng, Cineast and Cottontail DB [10].

gives a comprehensive overview of other systems at LSC 2020 and Section 6 concludes.

## 2 VITRIVR

vitrivr is a general-purpose open-source multimedia retrieval system, supporting various multimedia formats (e.g., video, images, audio, and 3D models) and query modalities (e.g., query-by-sketch, query-by-concept). vitivr has been a long-time participant at both LSC [9, 18] and VBS [10, 24, 25] with a relatively stable architecture consisting of three components: a database for multimedia features, Cottontail DB, the feature generation and retrieval engine Cineast, and a web-based front-end, vitivr-ng. In this section, we will give a brief overview of the individual components and their functionality for lifelog retrieval.

### 2.1 Architecture

Figure 1 shows a system overview of the vitivr stack. It consists of three major components, which reflect the clear separation of concern we try to implement in the stack:

**Database: Cottontail DB** is the database management system for multimedia retrieval offering support for both Boolean and similarity search [4]. In the context of LSC, we mainly rely on Cottontail DB’s ability to find exact matches for meta-data lookup (e.g., range queries) as well as full-text search.

**Retrieval Engine: Cineast** Cineast is the feature extraction and query processing engine of the vitivr stack [22]. Its modular architecture enables it to capture and combine various notions of similarity, as represented by different feature representations, both within and across multiple media modalities.

**Frontend: vitivr-ng** Written in TypeScript using the Angular<sup>1</sup> framework, vitivr-ng is responsible for query formulation, result presentation, browsing and filtering. Users can

combine various query modalities, for example, first filtering by time and then making a color sketch. Figure 2 shows a screenshot of the current UI.

### 2.2 Existing Functionality for Lifelog Retrieval

vitrivr has already participated to the LSC in previous years [9, 18] and has thus added functionality specifically for the lifelogging setting. In this section, we briefly summarize the extensions made for previous LSC participations.

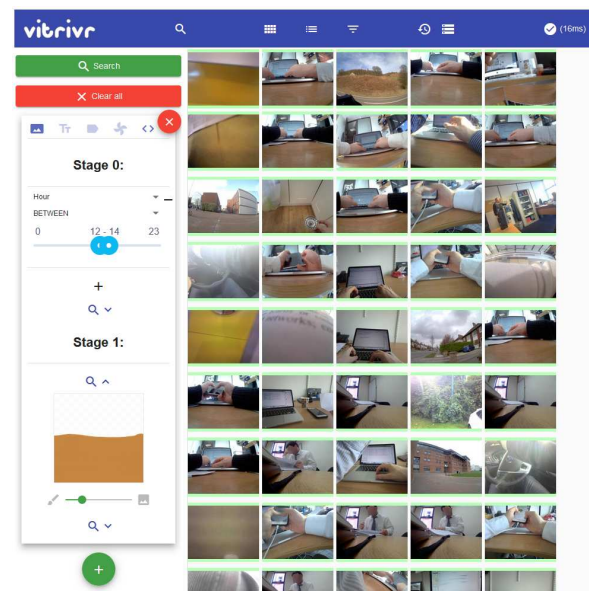


Figure 2: Illustrative screenshot of the user interface with a staged query.

<sup>1</sup><https://angular.io>

**Image Sequence Media Type.** Cineast’s data model is centered around *media objects* that can further be sub-divided into *segments*. Features and metadata can then either belong to a media object or a segment. Originally, Cineast only supported simple media types as media objects, such as single images, videos or audio files. Since LSC is centered around sequences of images that belong to the same day, we have added a new media type called an *image sequence* to accommodate these requirements. Similarly to how videos consist of different shots, image sequences contain multiple images that belong together, i.e., the sequence itself is the media object while the individual images are regarded as segments. Features can then be generated on a segment level (e.g., location of an individual image) or on an object level (e.g., day of the week).

**Boolean Queries.** The original version of Cineast mainly offered support for similarity search and fulltext search on certain units of information, such as extract scene text or speech. Even though it was always possible to store metadata on both a media object and a segment level, that data was usually not queried.

For LSC 2019, we added explicit support for Boolean queries to Cineast, supporting classical operators such as greater / less than, equals and between. These can be used to search in the provided metadata such as location information, weekday, year, etc. Based on that, later versions have also added support for combining Boolean and similarity search using *staged queries* [12] (see fig. 2).

**Result Filters.** In contrast to content-based multimedia retrieval, which is often based on the notion of similarity, LSC provides us with binary predicates such as *"It was a Saturday in 2016"*. We make use of this in two ways: First, staged queries allow us to apply such filters already during the query formulation phase, allowing the retrieval engine to seamlessly combine Boolean predicates with similarity search. Second, to avoid re-execution of the query once new information appears, we have also added late filtering based on all the metadata provided along with query results, which exclusively takes place in the front-end. This feature could be used to quickly reduce the result set as new information becomes available during the competition, without the need for another round-trip to the retrieval engine.

### 3 NEW FUNCTIONALITY FOR LSC 2021

#### 3.1 Image Stabilization

The images obtained from a lifelog camera occasionally suffer from degraded spatial quality due to the movements of the lifelogger and the lack of focus of the camera, which result in a blurry image. This image degradation could potentially reduce the performance of the spatial feature extractions, which are dependent on the clear boundaries between the objects and the background in the scene. To diminish this problem, we utilize an image stabilization method to reduce the noise and blur and produce a clean image to use at the feature extraction stage.

For this purpose, we use the multi-stage image stabilization method [31], which has state-of-the-art performance in real-world datasets for various restoration tasks such as deblurring and denoising. The method uses multiple stages of encoder-decoders where their outputs are fused together employing a cross-stage supervised attention mechanism. This deblurring process is especially helpful



**Figure 3: The result of image stabilization on a sample from the dataset. The images on the left are the original and on the right are the result of deblurring process.**

in scenes where the motion blur is the dominant type and the direction of the motion is uniform. We use the official implementation of the method provided by the authors<sup>2</sup> for deblurring the images in the LSC dataset prior to the feature extraction. Example outputs of the method are shown in Figure 3 where the amount of motion blur on the food caused by the movement of the lifelogger is reduced.

#### 3.2 Map-based Queries and Result Presentation

Spatial queries in Cineast are executed as nearest-neighbour search using the *haversine distance* on a two-dimensional vector of longitude and latitude, resulting in an approximation of the great-circle distance of any two given points [2]. Given a distance  $d$  between two points and a divisor  $x$ , we use a hyperbolic correspondence function to calculate the score  $s$  of a segment as follows:

$$s = \text{clamp}\left(0, \frac{1}{\left(1 + \frac{d}{x}\right)}, 1\right) \quad (1)$$

In the context of same-city queries, as used in [26], we found empirically that a maximal distance of 1000m results in reasonable ranks.

As described in Section 4, in the context of LSC, the spatial information is provided as metadata and imported into Cottontail DB. Geo-based queries can be performed in two ways: First, by specifying a circle on a map, allowing the user to express their uncertainty about a location, and second, by entering semantic names provided in the data set (e.g. "home", "work"). The coordinates of these locations are based on the provided metadata. Temporal context can be expressed similarly to all other modalities. Figure 4 shows how the map-based query modality looks like.

For LSC 2021, we plan to update vitivr-ng to include a map-based result view in addition to the existing views.

<sup>2</sup><https://github.com/swz30/MPRNet>

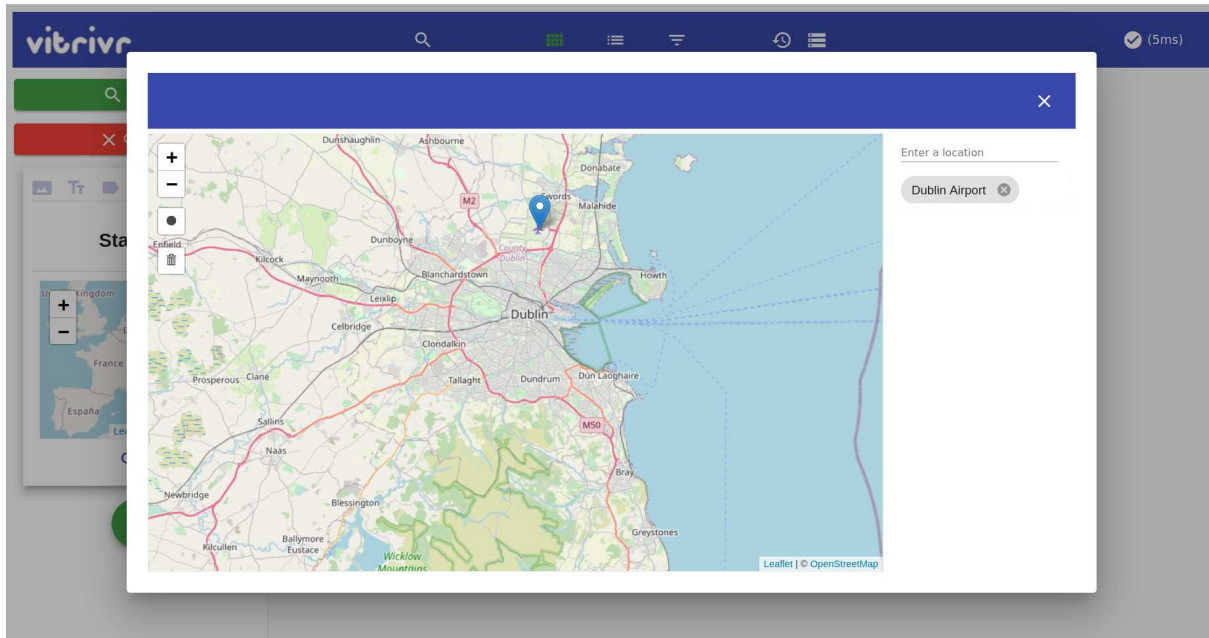


Figure 4: Illustrative screenshot of the map-based query by semantic location.

#### 4 DATASET PREPARATION

In comparison to the 2020 installment of the LSC, the data set changed only slightly and as a consequence, we applied the same data preparation steps as discussed in [9]. An overview of the data set can be found in [8]. In order to support the recent additions to the vitrivr system, as described in Section 3, we enhanced the data slightly: Spatial metadata is imported as a two-dimensional vector consisting of longitude and latitude and transformed from simple, table-like metadata, into feature data usable for similarity queries. Additionally, we are using the Microsoft Cognitive Service Annotations provided by the Myscéal [29] Team. We treated them as an expansion to the provided visual concepts which will be usable for input in Boolean- and *tag*-queries in vitrivr as introduced in [18]. For instance, this enables users to query for “all images with the concept *person*”.

#### 5 RELATED WORK

The Lifelog Search Challenge brings diverse multimedia retrieval systems together. Some of last year’s LSC participants, such as Exquisitor [28] and Li et al. [15], allow the user to specify whether they find particular results relevant or not. The system then uses this information to improve the result set.

Exquisitor is an interactive learning system, with users deciding which images of a suggested collection match the description on a given LSC task. The user either accepts or declines an image, and the system tries to provide new results based on user feedback. In the system of Li et al., users can exclude similar images from the result set.

VIRET [13], vitrivr [9], and Myscéal [29] offer temporal queries to express an information need that spans multiple, consecutive shots, with vitrivr and Myscéal offering the ability to indicate in

which time interval the described scenes happened. Many systems provide the functionality of filtering by day and hour, meanwhile others provide temporal context by showing images and respective shots taken before and after [14, 17, 28, 30].

Most of the systems offer querying by location. For our work the systems Myscéal [29], LifeSeeker [14], and the work of Chu et al. [3] are particularly interesting, since they provide a visualization of spatial context with the help of a map in various different ways:

*Myscéal.* In Myscéal, the user can query a location by drawing a rectangle on a map. Furthermore, the user does not have to explicitly query a location, since a default map is provided. If the user enters a text query, the map shows the locations of the result images. When the user hovers over the locations on the map, the respective images in the result set are highlighted – or vice versa.

*LifeSeeker.* LifeSeeker represents spatial context by using a directed graph in which a vertex depicts a location and an edge the chronological order of visited places. There are three granularity levels of the graph: On the first level, the vertices depict, for example, a place in another country, the second level shows more detailed locations (e.g., home, work, airport etc.) and the third level indicates, for example, in which room of the lifelogger’s home an image has been taken. The user can then click on a vertex and associated images will be presented. In addition to that, the system recognizes and suggests movement patterns of the lifelogger.

*Chu et al.* The system of Chu et al. also embeds a map but with the purpose of helping the user to recall all locations that have been visited by the lifelogger, where the visited cities are marked with a pin. Since the focus lies on guiding the user, it is at currently not possible to create a query by indicating the desired location on the map. However, it is possible to query a location by entering a place



as keyword.

A completely different approach in user interaction is taken by Voxento [1]. In Voxento, a user can create, delete and execute queries by speaking. The user can then manually edit the text which the system extracted from the user's spoken sentence. The results are updated in real-time while the user is adding more information. The system is able to respond and tell the size of the result set or the metadata of a selected image.

## 6 CONCLUSION

In this paper, we discussed the 2021 participation of the vitivr system in the LSC. vitivr uses a combination of query modalities, such as concept-based and OCR text retrieval, color and semantic sketches, and traditional Boolean queries. For this iteration of the LSC, we have added a new map-based query mode and result presentation. Moreover we have also integrated image stabilization techniques into vitivr. These techniques can be applied to images prior to feature extraction with the objective to increase the quality of the image features and thus to improve the entire retrieval approach for lifelogging data.

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